State Water Survey Division
SURFACE WATER SECTION
AT THE
UNIVERSITY OF ILLINOIS

Illinois Institute of Natural Resources

SWS Contract Report 259

IDENTIFICATION AND PRIORITIZATION OF STUDY NEEDS RELATED TO THE PHYSICAL, CHEMICAL AND BIOLOGICAL IMPACTS OF NAVIGATION ON THE UPPER MISSISSIPPI RIVER SYSTEM

Submitted to:
Environmental Work-Team
Upper Mississippi River Basin Commission

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December 24, 1980

PREFACE

The expansion of the navigation system on the Upper Mississippi River System (UMRS) related to the replacement of Locks and Dam 26 sometime in the late 1980's will undoubtedly add to the conflicts presently being waged between various users of the system. Since the UMRS is a public resource, it is necessary to prevent any one interest from dominating the resource and restricting its use by other sectors of society. We need to take every step to predict if and how such a situation might occur. Our ability to predict future conditions is limited, however, by a variety of factors. The purpose of this report is to describe what we know and what we don't know about the present and future physical, chemical, and biological impacts of navigation system expansion on the UMRS.

Included in this report are sections describing studies and programs to offset our lack of information about specific impacts. Earlier recommendations for studies to provide such information can be found in the following reports:

1) Board of Engineers for Rivers and Harbors. 1976. Summary of report on Locks and Dam 26. 91pp. 24 February.

2) Upper Mississippi River Basin Commission. 1979. Navigation and the environment, Upper Mississippi River main stem Level B, Technical Paper D.

3) Midwest Research Institute. 1978. Environmental and social considerations of Mississippi River, year-round navigation program. Final Report. Rock Island District, Corps of Engineers. 72pp.

4) Carlisle, J.B. 1977. Navigational uses of the Illinois River and associated research needs. p. 57-61. _In_: Future problems and water resources research needs of the Illinois River System. P.C. Welch, ed. Water Resources Center Special Rept. No. 6, Urbana, IL.

5) Institute for Water Resources. 1980. Analysis of environmental aspects of waterways navigation. Review Draft. Fort Belvoir, Virginia: Water Resources Support Center.

6) Solomon, R.C., D.R. Parsons, D.A. Wright, B.K. Colbert, C. Ferris. 1975. Environmental inventory and assessment of navigation pools 24, 25, and 26, Upper Mississippi and Lower Illinois Rivers; summary report. Vicksburg, Mississippi, Army Engineer Waterways Experiment Station. 100pp.

INTRODUCTION

This report has been prepared jointly by the Illinois Natural History Survey and the Illinois State Water Survey. It is the product of Phase I, Tasks 2, 3, 4, and 5 of the Navigation Effects Study which called for a summary of existing information and the identification and prioritization of future study needs related to the physical, chemical, and biological impacts of the navigation on the Upper Mississippi River System (UMRS). The UMRS as defined here includes the navigable reaches of the system above Cairo, Illinois. An earlier report, "Information Summary of the Physical, Chemical, and Biological Effects of Navigation " (Lubinski et al. 1980), included a review of the literature related to navigation effects and a brief list of information gaps.

This report has been organized into two sections, one dealing with physical and chemical impact information (by the Illinois Water Survey),. the other with biological impact information (by the Illinois Natural History Survey). This organization enabled us to separately present the ideas of both agencies and provide the opportunity for readers to compare them for differences and similarities.

The internal organization of each section in this report has been standardized to include subsections on areas susceptable to impacts within the UMRS, state of the art of impact measurement, information gap lists, studies to fill information gaps and prioritization of study needs.

I. IDENTIFICATION AND PRIORITIZATION OF STUDY NEEDS ON THE PHYSICAL AND CHEMCIAL IMPACTS ON NAVIGATION

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INTRODUCTION

This report completes the review of existing information and the identification of information gaps on the impacts of navigation on the physical and chemical characteristics of the Upper Mississippi River. Studies which are needed to fill or narrow the information gaps are outlined and a prioritized listing is presented. Locations where impacts may take place are discussed first. A brief review of the "state of the art" knowledge of the impacts of navigation on the physical and chemical characteristics of a river is presented before the information gaps are. listed. The information gaps and related study needs are separated into two groups related to construction, operation, and maintenance of the navigation project on the UMRS or to commercial and recreation vessel traffic.

AREAS SUSCEPTIBLE TO IMPACTS

Project Construction, Operation and Maintenance

When the 9-foot channel projects were completed, erosion and sedimentation processes began to rebalance the stage, discharge, and slope regime with the sediment supply. These historical effects of lock and dam construction have been described by Chen and Simons (1979). Unless new structures are built at locations substantially removed from the present lock and dam structures or with different water surface elevations there will be little future change in the Upper Mississippi River due to construction. Similarly only new wing or closing dams will have easily measured effects. The most likely type of construction with significant effects will be new fleeting areas. The effects will be adjustment of flow and erosion-sediment patterns in the vicinity of the changed river bed or banks in the new fleeting area.

Shoreline protection to curtail bank erosion will have effects on either end of the protected reach as well as along the reach itself. In some cases shoreline protection will move the area of active bank erosion to the ends of the protective structure.

Pool level regulation within the normal range of water surface elevations will have little physical effect unless the rate of change is rapid enough to cause sloughing of banks.

Dredging and dredge-spoil disposal have been much studied and the effects of dredging are described in a GREAT II draft report (1980).

The filling of side channels and backwater lakes with sediment has been documented by McHenry et al. (1976) and Sparks et al. (1979). Initial pool construction increased the surface area and water depth of off-channel areas. Since that time they have tended to fill with sediment from direct runoff, flood inputs, and pulse inputs caused by commercial tows.

Commercial and Recreational Vessel Traffic

Navigation by power vessels of any size has some effect on the river system. The magnitude of the effect depends on channel geometry and vessel characteristics; primarily the relationships between the vessel speed and wave celerity, vessel draft and channel depth, and the cross-sectional areas of the vessel and channel. The direct results of vessel passage are velocity and pressure fields resulting from water displacement by the vessel's hull and the propeller jet or jets and vessel-generated waves.

The velocity and pressure fields, especially the propeller jets, cause suspension or resuspension of sediments from the channel bed. The lateral dispersion of the vessel wake causes some of these suspended materials to move laterally into channel border areas where it settles out. The resuspension also increases the downstream movement of sediment. Velocity associated with the displacement of water by the vessel results in pulse movement of water with suspended sediment concentrations higher than ambient in the inlets and outlets of side channels and backwater lakes.

These effects occur along the entire river system. The amount of traffic, especially by commercial tows, and the channel geometry determine the magnitude of the impact on sediment movement and deposition. Detailed traffic analysis by class of vessel and season of the year is needed to predict the effect in a specific reach.

Vessel-generated waves have a direct effect on bank erosion and sediment suspension in the near-shore zone. The waves travel with little energy loss, but do dissipate with distance from the vessel track. Thus vessel-generated waves are more important in narrow channels or where the sailing line is close to the shore. In addition to seasonal traffic statistics, information on wind-generated waves is needed to determine the relative impact of these two types of waves on bank erosion and sedimentation.

Increased vessel traffic may increase the number of accidents. The physical effects of accidents include shoaling, flow and traffic blockage, channel obstruction, damage to vessels and structures along or in the river. Each accident is a particular combination of vessels, structures, channel, and circumstances. Thus the affected area is peculiar to that accident.

<u>Chemical Impacts</u>

Water quality impacts are primarily associated with the movement of sediment and the chemical processes involving sediment and aeration by the propeller jets. Thus chemical effects of vessel traffic are more intense where resuspension or deposition of sediment is more affected. Water quality changes due to construction are probably no longer detectable except by comparison of historical water quality data. Any project studying construction of new fleeting areas or other structures in the river should include water quality measurements.

Accidents involving spills of chemical or petroleum products present specific cases that can be studied and will have definite, perhaps serious, affects on the river biosystem or municipal water supplies near and downstream from the accident site.

Vessel wastes and pollution are chemical in nature and occur wherever there is vessel traffic. Fuel and oil leakage and spills are probably : most important and will be more significant near marinas, docking, and fueling areas. Cooling system oil leaks and outboard motor exhaust contaminants will be present in proportion to the number of vessels and the amount of traffic in any given reach.

STATE OF THE ART

A brief review of the state-of-the-art is presented for general alluvial river mechanics and sediment transport, propeller jet flow, resuspension of sediment, sedimentation in side channels and backwater lakes, vessel and wind generated waves, bank erosion, and dispersion. A more detailed treatment would involve synthesis of the material contained in the definitive articles referred to for each topic and development of new or modified theories and analytical methods. Though not all the references cited were included in the Phase I, Task 1 report, all are in the Water Survey files on the physical and chemical effects of navigation. These files include about 350 items as of October 30, 1980.

Upper Mississippi River System

General information is available from Upper Mississippi River Basin Commission reports such as the Main Stem Level B Study (1980) and Corps of Engineers studies such as the Upper Mississippi Comprehensive Basin Study (1970). The Great River Environmental Action Team has published two studies (1979, 1980) reviewing all aspects of the river above Saverton, Missouri and has work on the lower portion of the river in progress as GREAT III.

The effects of construction of the 9-foot channel are described by Chen and Simons (1970) and McHenry, Richie, and Verdon (1976). Their major contribution concerns the changes in morphology of the river channel and off-channel areas due to pool construction, wing dams, and changes in sedimentation. Chen and Simons conclude that the geomorphic changes of the existing navigation system are essentially complete and little future change other than continued sedimentation in off-channel areas will occur unless major structural changes are made. Illinois Natural History Survey researchers have detailed the changes in fish and wildlife habitats on the Illinois River resulting from the construction of the 9-foot navigation channel (Sparks et al. 1979 and Bellrose et al. 1977).

Sediment Transport

General

The water and sediment discharge capacities of natural rivers present a complex system involving geology, hydrology, and fluid mechanics. Construction of a slack-water navigation system changes the stage-discharge relationship and the sediment supply-capacity characteristics of a river. Complete treatment of sediment transport is given in books by Graf (1971) and Simons and Senturk (1977). The American Society of Civil Engineers (Vanoni, 1975) has published a manual of practice on sediment engineering. Researchers at Colorado State University have published their work on rivers (Simons, et al. 1976) and have done some specific studies on the Upper Mississippi River (Simons et al., 1975).

More specific studies describe sedimentation rates in the Upper Mississippi River Basin (McHenry, Richie and Verdon, 1976) and sediment transport in the Illinois River (Lee and Bhowmik, 1979). Livesey (1970) identified the interrelations between sediments and water quality.

The analytical methods are fairly well developed and are usable if sufficient input data are provided. The complex interactions between the sediment parameters and flow characteristics continue to make predictive computations of sediment discharge only qualitative. The effects of lock and dam or closing dam construction on erosion, deposition, and sediment transport capacity are addressed by several of these references. The question of vessel traffic resuspending sediment which then dispersed laterally has been addressed only recently and is discussed next.

Propeller Jets

The highest velocities and turbulence levels are associated with the vessel propellers. The velocities along the channel bottom are much less than those at the propeller itself but can be high enough to resuspend particles settled on the channel bottom. There is a large amount of literature on the fluid mechancis of jet flow. Liou and Herbich (1976) applied the jet momentum analysis and Shields' sediment entrainment diagram to resuspension of sediment by ships in restricted channels. Hochstein (Berger & Associates, 1980a, b) has recently reviewed the literature on several aspects of navigation effects on rivers and recommends his own modification of the theory for propeller jet velocity. This appears to give more reasonable velocities near the propeller than the Liou and Herbich solution and gives similar velocities farther from the propeller. The Water Survey intends to assess these theories and adopt the best method for use in its own study of sediment resuspension.

Resuspension and Lateral Movement

Visual observations of vessel wakes identify a plume of higher sediment concentration. Karaki and van Hoften (1974) used infrared photograph to help see the turbid plume and derive a qualitative understanding of the resuspension and movement of sediment by barge tows. Johnson (1976) made the first field measurements of increased turbidity and suspended solids behind tows. He also obtained data on dissolved oxygen concentrations. A related study was done by Link and Williamson (1976) who tried to correlate infrared images with surface water suspended solids concentrations. Correla-ation was poor and there was a lot of interference from sun glint and waves. The technique produced qualitative description of the tow-generated plume under favorable conditions. More detailed concentration measurements, especially of velocity-proportional samples, are needed to determine the amounts of resuspended sediments and the rate of movement of these sediments to channel border areas.

Side Channels

Off-channel areas receive water and sediment inputs from direct run-off, high stages in the main river, and pulse flows resulting from drawdown during tow passage. Sparks, et al. (1979) and Bellrose, et al. (1977) studied the changes in wildlife habitat resulting from the construction and operation of the 9-foot navigation channel on the Illinois River. They observed pulse inputs in Che inlets to backwater lakes as tows passed the inlet. Lee and Stall (1976, 1977) measured sedimentation rates in backwater lakes along the Illinois River.

Water and sediment flux analyses are needed to determine the relative importance of the three sources of the materials that settle out in off-channel areas. The most complete study would determine the sediment budget for specific backwater lakes and side channels.

Waves

There is a vast amount of theoretical literature on wind waves in oceans or lakes and on the generation of waves by vessels. Boat and ship generated waves are treated in detail by Gadd and Hogben (1963), Das (1969), Sorenson (1967, 1973), and Gates (1977). Propulsion power requirements and resistance to motion are of primary interest, though wave height and energy are also treated in these papers. Bhowmik (1975) described an experiment on boat-generated waves in a lake. Hay (1968) and Herbich and Brahme (1977) dealt with ship-generated waves in restricted channels. Hay used models to obtain wave data for various types and sizes of vessels in various water depths. Herbich and Brahme determined maximum velocities on the channel bottom using several wave theories. Recently Hochstein has reviewed the generation of waves by barge tows on the Ohio River (Berger, 1980a, 1980b). This is the most complete reference available. However, he limits his treatment of waves to the maximum wave height and the most significant wave type for different tow sizes and speeds. Presumably wave theories can be used to obtain wave train characteristics approaching the channel banks. Data on vessel-generated wave trains approaching the channel shore would be a valuable addition to the understanding of the importance of this type of wave in the bank erosion process.

Bank Erosion

The general causes of bank erosion are well known. However, the proportion of erosion at a particular site caused by one impact is very hard to determine. Also, the combination of bank material and stability and wave, velocity, or pressure, that results in erosion is very complex and make quantitative prediction nearly impossible.

Hurst and Brebner (1969) defined the impact of ship navigation on shore erosion along the St. Lawrence Seaway. Camfield, Ray, and Eckert (1979) reviewed all aspects of stream bank erosion including waves, ice, floods and navigation. Lovejoy and Kennedy (1970) assessed the use of bank projection to preserve or enhance wildlife habitat. Bhowmik and Schicht (1980) studied bank erosion along the Illinois River. They concluded that most shoreline erosion is caused by wind waves and vessel traffic. They recommend a monitoring program for bank erosion and vessel as well as wind wave measurements to determine the magnitude of the effect of both types of waves.

Dispersion

The lateral movement of resuspended sediment and the area affected by pollution from accidental spills, or turbidity plumes from dredges depend on the dispersion process in the river as modified by vessel traffic and the navigation structures. Fischer (1967, 1969) proposed methods for determining the longitudinal dispersion properties of rivers. Holley and Simons (1975) conducted laboratory studies of the lateral dispersion in open channel flow. The theory is fairly well developed, however, complex geometry in river channels and the difficulties of measuring dispersion limit the use of dispersion models to qualitative or approximate analyses.

INFORMATION GAPS

This section reviews the information gaps identified by Lubinski et al. (1980) and lists those involving physical or chemical impacts of navigation on the river system.

Project Construction, Operation, and Maintenance

These gaps relate to structural means of providing or maintaining the project channel geometry. New construction is needed before some of these gaps can be filled. If work is started immediately, the last one or two high lock and dam structures on the Ohio River provide a unique chance to observe the effects of lock and dam construction. The data collection should begin with as-is conditions before project construction begins, include monitoring during construction, and conclude with continuous or occassional studies after construction until a stable system becomes established.

Information gaps have been identified for the effects of:

1. Lock and dam construction
2. Wing or closing dam construction
3. Fleeting area construction
4. Bank protection
5. Pool level regulation
6. Dredging and dredge spoil disposal
7. Side channel and backwater lake formation and sedimentation

Commercial and Recreational Vessel Traffic

The information gaps relating to vessel traffic are somewhat more specific and can be studied with short, specific projects. Some gaps deal with vessel propulsion and jet mechanics. Others arise from sediment resuspension or dispersion processes.

The information gaps are:

1. Resuspension of sediment by vessel propeller jets and velocity and pressure fields
2. Lateral movement of resuspended sediment
3. Pulse inputs to side channels and backwater lakes
4. Wind and vessel generated wave spectra
5. Velocity and pressure fields caused by vessels in main channels and channel borders
6. Wind and vessel traffic histories and projections
7. Bank erosion by waves
8. Seasonal considerations for waves, traffic, and bank erosion
9. Accidents
10. Vessel wastes and pollution

STUDIES TO FILL INFORMATION GAPS

These studies are outlined briefly. There are six studies for gaps on construction, operation, and maintenance of the navigation system and seven studies for gaps on vessel traffic impacts. Manpower needs and cost estimates are based on the project proposals perpared by the Water Survey for the Environmental Work-Team of the UMRBC Master Plan Task Force. No future inflation factor is used, so longer study plans will cost more than indicated. Also, several studies should be continued past the proposed period on a long-term monitoring basis. Sedimentation effects of construction are an example of this type of study. An accident impact assessment team is recommended and operating costs of this project depend on the frequency and severity of major accidents involving commercial vessels. The studies are listed in an order similar to the information gaps. The lists are not identical because some studies can best be combined and other gaps are beyond current methodology.

Project Construction, Operation, and Maintenance

C1. High lock and dam construction: survey changes in stream regimes, sediment load and bank stability before, during, and after construction or replacement

Site - At a high lock and dam construction site

Study Period - 5 years

Manpower - 110 man-months

Funding - $303,000

C2. Wing or closing Dam construction: sediment, turbidity, and flow conditions before, during, and after construction

Site - At a site under construction

Study Period - 2 years intensive survey during construction and then occasional surveys for the next 3 years

Manpower - 69 man-months

Funding - $190,000

C3. Fleeting Area construction: sediment, turbidity, and water quality surveys before, during and after construction

Site - At a site under construction

Study Period - 4 years

Manpower - 84 man-months

Funding - $231,000

C4. Bank Protection: Survey and monitor bank stability at construction site and also upstream and downstream of the construction site.

Site - At the site of a bank protection structure

Study Period - 5 years

Manpower - 110 man-months

Funding - $303,000

C5. Pool Level Regulation: Investigate the effect of pool level fluctuations on bank stability.

Site - Upstream of lock and dam structure and downstream

Study Period - 2 years

Manpower - 24 man-months

Funding - $66,000

C6. Dredge Spoil Disposal: Monitor the sediment return rate from disposal areas and the effectiveness of dredging at different locations. The first phase of the study should be to compile and analyze existing dredging information. The second phase of the study should include site specific monitoring program for several years.

Site - At dredging and dredging disposal sites

Study Period - 2 years for office work to compile and analyze existing data; 5 years to monitor specific dredging and disposal areas

Manpower - 54 man-months

Funding - $149,000

<u>Commercial and Recreational Vessel Traffic</u>

T1. Velocity and Pressure Studies: Measure velocity and pressure induced by the passage of vessels along river channels. Conduct laboratory experiments to develop mathematical relations between vessel movement characteristics and the resulting pressure and velocity changes along the river bed and banks.

Site - Selected reaches along the rivers

Study Period - 3 years of field data gathering and 2 years of laboratory experiments and model development

Manpower - 48 man-months

Funding - $182,000

T2. Resuspension of Sediments: Suspended sediment measurements after the passage of vessels and laboratory experiments to investigate the turbulence and velocity at the river bed induced by propeller jets under Various boundary configurations

Site - Selected reaches along the rivers

Study Period - 3 years of field data gathering and 3 years of laboratory experiments and model development

Manpower - 144 man-months

Funding - $396,000

T3. Lateral Movement of Sediments: Suspended sediment measurement after the passage of vessels at several locations across a cross-section at selected reaches of the rivers. Develop a methodology for collection of such data with acceptable accuracy. Establish relations between traffic pattern and lateral movement of sediment

Site - At selected reaches within several of the pools

Study Period - 3 years

Manpower - 126 man-months

Funding - $347,000

T4. Pulse Inputs to Side Channels and Backwater Lakes: Discharge and sediment input and output measurements and analyses for selected side channels and backwater lakes during vessel passages.

Site - At selected side channels and backwater lakes

Study Period - 3 years

Manpower - 108 man-months

Funding - $297,000

T5. Waves Generated by Vessels and Wind: Measure wave heights and patterns generated by various types of vessels and wind conditions at several reaches of the rivers with active bank erosion problems. Analyze and simulate the waves generated under different river traffic patterns and during the different seasons.

Site - At selected reaches along the river

Study Period - 3 years

Manpower - 96 man-months

Funding - $264,000

T6. Accidents: Dispersion studies for accidental spills on the Mississippi and Illinois Rivers. Develop or adopt applicable mathematical models capable of estimating travel time and concentration levels along the river. Establish a Task Force to survey the nature and extent of accidents along the waterways

Site - The whole navigable waterway

Study Period - 2 years

Manpower - 39 man-months

Funding - $107,000

T7. Vessel Wastes and Pollution: Water quality monitoring in and around fleeting areas and marinas

Site - Fleeting areas and marinas

Study Period - 5 years

Manpower - 45 man-months

Funding - $124,000

The studies outlined here total 6 projects for a total cost of $1,242,000 for pool construction, operation, and maintenance; and 7 projects for a total cost of $1,685,000 for vessel traffic effects. Study time periods range from 2 to 5 years. The total cost over 5 years is $2,927,000 for 13 studies. The time, manpower, and cost figures are preliminary estimates extrapolated from proposals for similar studies recommended for investigation in Fiscal Year 1981. The accident monitoring task force coordination for two years is within the scope of the study. However, field inspection and surveillance of an individual accident could cost from $1,000 ro $25,000 depending on the magnitude, severity, and danger to humans or critical wildlife resources.

PRIORITIZATION OF STUDY NEEDS

The 13 studies outlined above are of differing importance, address subjects in varying states of understanding, and range in scope from 2 years and $66,000 to 6 years and $396,000. A priority listing will be of aid in selecting studies for immediate work.

Six factors are considered in developing the priority list of studies.

1. Study time scale - Long-term monitoring studies score less than definite term studies.
2. Need for data - Studies to produce needed but unavailable data score ahead of those which compile or analyze existing data.
3. Impact - Magnitude of impact on the physical and chemical regime of the river system.
4. Proportionality to traffic levels - Studies of impacts which are expected to be proportioned to traffic levels score higher than those with little or no relation to traffic level.

5. State of the art - Higher scores are for available data, known methodologies, and clearly defined parameters; lower scores go with lack of knowledge.

6. Area of impact - System-wide impacts score more than local impacts.

Each study is rated by these criteria using the technical knowledge and engineering experience of the authors. The studies are assigned to one of three priority classes based on an overall assessment of the criteria and professional judgments. The three priority classes are:

I. Urgent

II. Necessary

III. Beneficial

The studies are listed within each class with pertinent comments on the criteria. There are six Class I studies, Two Class II studies, and five Class III studies. Listing within a class does not imply any rank or priority. Studies are listed in numerical order.

Class I: Urgent

C6. Dredge spoil disposal.

The final location of dredge spoil that is not retained permanently in disposal areas is critical to determining the most efficient methods of spoil disposal. Data is needed and can be obtained in a 5 year period with refinement of existing instrumentation. Local areas are affected throughout the system and relation to traffic density is uncertain.

T1. Velocity and pressure studies.

Flow field data are urgently needed for both physical and biological impact studies. Field measurements are difficult, but laboratory studies can be used effectively in a 2-year period.

Instrumentation and analytical methods need some development for the field study. There are definite impacts, along the entire navigation system and these impacts are proportional to traffic levels.

T2. Resuspension of sediments.

This is an extension of T1. Laboratory studies will define the area behind a vessel in which sediment is resuspended. Concurrent field and laboratory studies will take 3 years. Impact is system-wide and proportional to traffic level. Theoretical and laboratory methods are available and field methods need some refinement.

T3. Lateral movement of sediments.

Knowledge of the location where resuspended sediment settles to the river bed is crucial to the sedimentation and biological regimes. Impacts occur along the entire system and are proportional to traffic levels. Suitable methods for collecting field data are being developed.

T4. Pulse inputs to side channels and backwater lakes.

Sedimentation of off-channel areas is a major impact along the entire system, especially the Illinois River and the northern part of the Mississippi River. Traffic level is a factor and quantitative measurements are needed. This is one part of a sediment budget for a given side channel. Existing methodology can be easily adapted.

T5. Waves generated by vessels and wind.

Bank erosion is the primary impact of waves and occurs at specific sites throughout the system. Analytical and instrumental methodologies are available for wave measurement, interpretation, and prediction. Vessel-generated waves are directly related to traffic levels. Wind waves depend on wind speed and direction and fetch.

Class II: Necessary

C3. Fleeting area construction.

Site specific studies will determine the impact of fleeting area construction. Methodology is available. The impacts are local and proportional to traffic levels only in the sense that more traffic requires more fleeting facilities. A new fleeting area should be identified and studied for four years.

C4. Bank protection.

The success of bank protection projects is measured by the elimination of erosion, not by temporarily arresting erosion or shifting the impacted area. Field measurements can be done with existing equipment and procedures. Local areas are impacted and the impact may be proportional to traffic level. There are no extant data on the effect and success of bank protection projects.

Class III: Beneficial

C1. High lock and dam construction.

This 5 year study depends on construction of a new structure that will change pool levels in a substantial reach of river. Continued sedimentation surveys will be needed for 10 to 50 years to determine the ultimate effect of the structure. Impacts are major, not proportional to traffic except near the locks, and specific to the two pools separated by the structure. Data should be obtained when and where possible with available methodologies.

C2. Wing or closing dam construction.

Study of the effects of construction depends on installation of a new wing or closing dam. The proposed study is for 5 years, but long-term monitoring is needed for 10-20 years or until a stable condition is established. Impacts are local, though there are many such structures along the Upper Mississippi River. Impacts are not directly proportional to traffic levels. Systematically collected data are needed and can be obtained with existing methods.

C5. Pool level regulation.

Two years is adequate if the parameters have been determined, data needs have been identified, and theoretical and instrumental methods have been developed. Physical and chemical impacts are probably not very significant. The area of impact is specific to the pool being regulated.

T6. Accidents.

The 2-year project provides for compilation of existing accident reports and application of dispersion models to chemical spills at accident sites. Physical impacts are limited to channel blockage and local scour or deposition. The task force would be most important and should be an ongoing program and would need to be supported by a contingency fund to accommodate the random occurrence of accidents. Affected areas are specific to each accident and the magnitude of impacts depends on the severity of the accident and the release of chemicals or petroleum products.

T7. Vessel waste and pollution.

Five years will determine the scope of this problem, though continued monitoring is needed. Impacts are proportional to traffic levels and occur throughout the system but are more significant at fleeting areas, loading docks, and marinas. The effects are chemical and definitive data are needed. Water quality monitoring techniques are well developed.

SUMMARY

The priority listing of 13 proposed study needs includes six in Class I: Urgent, with an estimated cost of $1,635,000; two in Class II: Necessary, with an estimated cost of $534,000; and five in Class III: Beneficial, with an estimated cost of $790,000. These costs do not include long-term monitoring studies which are also necessary.

As specific study proposals are developed the scope and cost estimate will be refined. Additional study needs may also be identified in the course of developing detailed proposals or conducting specific studies.

If the biological studies require immediate information on a physical or chemical impact, the priority of a given study may be changed to meet this need.

REFERENCES

Bellrose, R.C., R.E. Sparks, F.L. Paveglio, Jr., D.W. Steffeck, R.C. Thomas, R.A. Weaver, and D. Moll. Fish and wildlife habitat changes resulting from the construction of a nine-foot navigation channel from LaGrange Lock and Dam upstream to Lockport Lock and Dam. Prepared for U.S. Army Corps of Engineers, Chicago, District, Havana, Illinois. Ill inois Natural History Survey. 132pp, 1977.

Berger Associates, Ltd., and Louis Berger and Associates, Inc. Analysis of the effect of tow traffic on the physical components of the environment. Prepared for the U.S. Army Engineer District, Huntington, West Virginia. Draft. March 18, 1980.

Berger Associates, Ltd., Louis Berger and Associates, Inc., and Academy of Natural Sciences. Environmental and physical impact studies for Gallipolis Locks and Dam, Ohio River. Phase I replacement study, Volume II: navigation impact. In press, 1980.

Bhowmik, N.G. Boat-generated waves in lakes. Technical Note, ASCE J. Hydraulics Div. 101(HY11): 1465-1468. November, 1975.

Bhowmik, N.G., and R.J. Schicht. Bank erosion of the Illinois River. Illinois State Water Survey, Urbana. Report of Investigation 92. 1980.

Camfield, F.E., R.E.L. Ray, and J.W. Eckert. The possible impact of vessels wakes on bank erosion. U.S. Army Corps of Engineers, Coastal F.ngineering Research Center. 1979.

Chen, Y.H., and D.B. Simons. Geomorphic study of Upper Mississippi River. Journal Waterway, Port, Coastal, and Ocean Division, ASCE 105(WW3): 313-328. Proc. Paper No. 14778. 1979.

Das, M.M. Relative effect of waves generated by large ships and small boats in restricted waterways. Hydraulic Engineering Laboratory, College of Engineering, Univ. of California, Berkeley. 112pp. 1969.

Fischer, H.B. The mechanisms of dispersion in natural streams. ASCE J. Hydraulics Div. 93(HY6, Proc. Paper 5592): 187-216. November, 1967.

Fischer, H.B. The effects of bends on dispersion in streams. Water Resources Research 5(2): 496-506. 1969.

Gadd, G.E., and N. Hogben. An appraisal of the ship resistance problem in the light of measurements of the wave pattern. F.C. Michelson, cd. Proceedings of the International Seminar on Theoretical Wave-Resistance, University of Michigan, Ann Arbor. p. 273-337. August 19-23, 1963.

Gates, E.T., and J.B. Herbich. Mathematical model to predict the behavior of deep-draft vessels in restricted waterways. Texas A & M University. 169 p. 1977.

Graf, W.H. Hydraulics of sediment transport. McGraw-Hill Book Co., New York, New York. 513pp. 1971.

Great River Environmental Action Team, I. Main report draft. GREAT I Upper Mississippi River. Sept., 1979.

Great River Environmental Action Team, II. Plan formulation, main report. Great II Upper Mississippi River (Guttenburg, Iowa to Saverton, Missouri). . Draft. May, 1980.

Hay, D. Ship waves in navigable waterways. Proc. 11th Conference on Coastal Engineering, London, England. 1472-1487. 1968.

Herbich, J.B., and S.B. Brahme. Estimation and analysis of horizontal bottom velocities due to waves. College of Engineering, Report No. 202, Texas A & M Univ., College Station, Texas. 1977.

Holly, F.M., and D.B. Simons. Transverse mixing of neutrally-buoyant tracers in nonrectangular channels. Fundamental tools to be used in environmental problems: Proceedings of the 16th Congress of the International Association for Hydraulic Research, Sao Paulo, Brazil. Vol. 3, p. 467-474. July 27-Aug. 1, 1975.

Hurst, C.K., and A. Brebner. Shore erosion and protection. St. Lawrence River - Canada. Permanent International Association of Nagivation Congresses, XXIInd International Navigation Congress, Paris, Section 1, Subject 6. 45-56. 1969.

Johnson, J.H. Effects of tow traffic on the resuspension of sediments and on dissolved oxygen concentrations in the Illinois and Upper Mississippi Rivers under normal pool conditions. Technical Report Y-76-1, U.S. Army Engineer Waterways Experiment Station, Environmental Effects Laboratory, Vicksburg, Mississippi. 181pp. 1976.

Karaki, S., and J. vanlloften. Resuspension of bed material and wave effects on the Illinois and Upper Mississippi Rivers caused by boat traffic. CER 74-75SK-JV9, Colorado State University, Ft. Collins, Colorado. November, 1974.

Lee, M.T., and N.G. Bhowmik. Sediment transport in the Illinois River. Prepared by the Illinois State Water Survey for the Division of Water Resources, Illinois Department o£ Transportation, Contract No. 1-47-26-84-381-00, Illinois State Water Survey, Urbana. 1979.

Lee, M.T., and J.B. Stall. Sediment conditions in backwater lakes along the Illinois River. Contract Report No. 176, State of Illinois, Department of Registration and Education, Illinois State Water Survey, Urbana. 1976.

Lee, M.T., and J.B. Stall. Sediment conditions in backwater lakes along the Illinois River—Phase 2. Contract Report, State of Illinois, Department of Registration and Education, Illinois State Water Survey, Urbana. 1977.

Link, L.E., Jr., and A.N. Williamson, Jr. Use of automated remote sensing techniques to define the movement of tow-generated suspended material plumes on the Illinois and Upper Mississippi Rivers. Army - Engineer Waterways Experiment Station, Vicksburg, MS. 71pp. 1976.

Liou, Y.C., and J.B. Herbich. Sediment movement induced by ships in restricted waterways. Texas A & M University, TAMU-S6-76-209, COE Report No. 188. Aug. 1976.

Livesey, R.H. The role sediments play in determining the quality of water. Proc. seminar on sediment transport in rivers and reservoirs. Corps of Engineers Hydrologic Engineering Center, Davis, California. Paper No. 9. April 7-9, 1970.

Lovejoy, J.A., and D.M. Kennedy. Shoreline protection for habitat enhancement on the upper Mississippi River (an inventory of sites needing protection and a literature search and review). Prepared for the Fish and Wildlife Work Action Team. U.S. Army Engineers, St. Paul District, St. Paul, MN. 37pp. 1979.

Lubinski, K.S., H.H. Seagle, Jr., N.G. Bhowmik, J.R. Adams, M.A. Sexton, J. Buhnerkempe, R.L. Allgire, D.K. Davie, and W.P. Fitzpatrick. Information Summary of the physical, chemical, and biological effects of navigation. Prepared by the Illinois Natural History Survey and the Illinois State Water- Survey for the Environmental Sub-team, Master Plan Task Force, Upper Mississippi River Basin Commission. Draft. September 16, 1980.

McHenry, J.R., J.C. Richie, and J. Verdon. Sedimentation rates in the Upper Mississippi River. Third Annual Symposium on Waterways, Harbors, and Coastal Engineering Division, ASCE. Colorada State University, Ft. Colins, Colorado, vol. II. 1976.

Simons, D.B., Y.H. Chen, P.F. Lagasse, and S.A. Schumm. A summary of the river environment. Colorado State University, Ft. Collins, Co. 78pp. 1976.

Simons, D.B., J.A. Schumm, M.A. Stevens, Y.H. Chen, and P.F. Lagasse. Environmental inventory and assessment of navigation pools 24, 25, and 26, Upper Mississippi and Lower Illinois Rivers — A geomorphic study. Final Report. 1975.

Simons, D.B., and F. Senturk. Sediment transport technology. Water Resources Publications, Fort Collins, Colorado. 807pp. 1977.

Sorenson, R.M. Investigation of ship-generated waves. Journal Waterways and Harbors Division, ASCE 93(WWi): 85-99. Proc. Paper 5102. Feb. 1967.

Sorenson, R.M. Water waves produced by ships. Journal Waterways, Harbors, and Coastal Engineering Division, ASCE 99 (WW2): 245-256. Proc. Paper 9754. May, 1973.

Sparks, R.E., F.C. Bellrose, F.L. Paveglio, Jr., M.J. Sandusky, D.W. Steffeck, and C.M. Thompson. Fish and wildlife habitat changes resulting from construction of a nine-foot channel on pools 24, 25, and 26 of the Mississippi River and the lower Illinois River. U.S. Army Corps of Engineers, St. Louis, MO 208pp. 1979.

Upper Mississippi River Basin Commission. Report on the Upper Mississippi River Main Stem Level b (draft) Study. 132pp. June, 1980.

U.S. Army Engineer District, Rock Island, Illinois. Upper Mississippi comprehensive basin study, vol. 1: Main report. Prepared for UMRCBS Coordinating Committee. 1970.

Vanoni, V.A., ed. Sedimentation engineering. ASCE Manuals and Reports on Engineering Practice No. 54. 1975.

II. IDENTIFICATION AND PRIORITIZATION OF STUDY NEEDS RELATED TO BIOLOGICAL IMPACTS OF NAVIGATION ON THE UPPER MISSISSIPPI RIVER SYSTEM

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INTRODUCTION

This section has been prepared to identify information gaps related to the biological impacts of navigation on areas within the Upper Mississippi River System and to outline and prioritize studies to fill these gaps. The physical and chemical impacts of navigation were addressed in the first section of this report.

AREAS SUSCEPTABLE TO IMPACTS

Project Construction, Operation and Maintenance

Project Construction

The construction of the Upper Mississippi River lock and dam system in the 1930's resulted in the inundation of large areas of terrestrial habitat on both the Mississippi and Illinois Rivers. (U.S. Army, Corps of Engineers 1978, 1979). Since impoundment, increased sedimentation in backwater, side channel, and main channel borders, has resulted in progressive losses of aquatic habitats (Sparks et al. 1979, U.S. Army Corps of Engineers 1978, GREAT I Sediment & Erosion Work Group 1979). However, the general decrease in water velocities which accompanied impoundment is not the only factor that has affected sedimentation rates in different reaches or aquatic habitats in the UMRS. A key question related to increased sedimentation rates is: "What are the relative contributions to sedimentation in different reaches and habitats in the UMRS from erosion, flood events, dredging, pool construction, wing and closing dam construction, and boat traffic"?

Aquatic and semi-aquatic animal and plant population changes that have taken place since project construction have been reported by Starrett (1971), Fremling (1974), U.S. Corps of Engineers (1978), GREAT I Fish and Wildlife Work Group (1979), GREAT II Fish and Wildlife Work Group (1980a), Green (1960), Yeager (1949), and Sparks et al. (1979). In general, fish, waterfowl, and aquatic fur bearer populations increased with the increase in habitat, bottomland timber decreased, and a decrease in low-flow drying periods may have resulted in less "rejuvenation" of marsh soils. Lentic (still water) aquatic species tended to benefit from project construction while some lotic (running water) species suffered. Some migratory fish species declined in the pooled part of the river as did some mussel species that depended on these fishes to act as hosts for their larvae. In many cases, it has been difficult to relate long term changes in aquatic populations since the 1930's directly to project construction, since several other major environmental changes have occurred simultaneously. These environmental changes have included water quality degradation, riparian municipal and industrial development, buildup of toxic materials, and increases or decreases in the harvesting of aquatic populations.

The biological impacts summarized above were limited to the pooled reach of the UMRS. Biological impacts related to wing and closing, dam construction, however, extend as far downstream as Cairo, Illinois. The major beneficial biological impact resulting from wing and closing dam construction is the increase in habitat they provide for periphyton, aquatic insect larvae and crustaceans. Increases in these populations in turn benefit the fish that feed on them. Depending on their construction (length, shape, effect on river flow), wing dams can also provide preferable habitat for certain fish species. The primary long-term adverse impact of wing and closing dams is that they have increased sedimentation rates and thus reduced aquatic habitats in either main channel, side channel or backwater areas (depending on where they were located). As long as a primary goal of the navigation system remains to constrict the width of the main channel, there will be a conflict between fisheries and navigation interests.

Project Operation and Maintenance

Maintenance of more stable pool water levels since construction of the locks and dams has benefitted aquatic vascular plants on the Illinois River (Bellrose et al. 1977) but shortened low-flow drying periods of marshes which helped "rejuvenate" their soils. Operational drawdowns have stranded fish in shallow backwaters, increased the movement of fish from backwater to main channel habitats, and exposed benthic communities. Water level regulation practices are not, however, universal throughout the pooled reach of the UMRS. Even within a single pool, water level regulation practices are designed to maintain a minimum 9-foot depth at the pool's control point and water levels and velocities in other reaches of the pool may still fluctuate considerably. These differences make it difficult to predict biological effects of water level regulations at any one point in the system or over the entire pooled reach of the UMRS as a whole.

Bank stabilization activities have considerable adverse biological impacts on nearshore and bank communities along the main channel in both the pooled and non-pooled reaches of the UMRS. Solomon et al. (1975) noted that revetments are usually placed on unstable banks. But factors that have resulted in unstable banks in the UMRS vary at different sites and channel constriction practices, dredging and traffic-induced waves probably contribute to the problem in many areas. On the other hand, rock revetments may provide habitats for reptiles, amphibians and small mammals, and do provide substrates for aquatic periphyton and macroinvertebrates that prefer hard substrates. The major biological problem associated with bank stabilization, therefore, is whether new biological communities produced by bank stabilization are as desireable, in terms of production, diversity, and ecosystem function as the replaced community.

Potential biological impacts of winter navigation on the UMRS have been summarized by the Midwest Research Institute (1978). They considered the effects of winter navigation based on a 12-month navigation season below Grafton, Illinois; and a AO-week season to Cassville, Wisconsin. These impacts included: effects of resuspended sediments on benthos, effects of decreased light penetration on photosynthesis and the foraging activity of sight feeding fish, the increased potential for spills from commercial traffic, the effects of ice scour on bank and benthic communities, direct mortality to non-active fish in the main channel from propellor turbulence, effects of ice jams on water levels in backwater communities, and effects of water level changes on aquatic fur bearers. In general, few documentary reports are available to indicate the potential magnitude of these impacts or at which sites along the UMRS they would be most adverse.

Biological impacts of dredging and spoil disposal have been summarized by Allen and Hardy (1980), Hirsch et al. (1978), and Morton (1977). Impacts are highly site specific and dependent on the type of sediments dredged, the biological composition of the area dredged, and the biological composition of the area where the spoil is placed. Effects include habitat destruction (short and long term), physical damage to and removal or burial of organisms, exposure to toxic contaminants in the spoil, and dissolved oxygen stress created by sediment oxygen demand and turbidity-related lower photosynthetic rates.

Since much of the dredging done in the UMRS involves course sediments (fine to rough grained sand), the effects of contaminant release and ternporary turbidity increases are probably less important than short and long term habitat destruction and the burial of benthic organisms caused by spoil disposal and secondary movements of spoil into backwater areas. This may not be true for the Illinois River which has a shallower gradient than the Mississippi and is characterized by more areas that contain finer sediments. In any case, biological dredging impacts will undoubtedly have to be assessed in most cases on a site specific basis and stand little chance of being generally predictable over an area as large as the UMRS.

Cleaning and snagging is apparently conducted on a "when and where necessary" basis in the UMRS. In general, these activities remove cover and substrates from aquatic habitats in the UMRS and can adversely impact bank communities if heavy mechanical equipment is utilized from shore. The extent or magnitude of these activities on the UMRS is not well documented.

The need for additional barge fleeting areas on the UMRS will increase as the capacity of the lock system increases. The construction of a barge fleeting area can have several site specific biological impacts. These impacts include physical damage to benthic and bank communities, decreased dissolved oxygen levels due to resuspended sediments, and the disruption of localized fish movement patterns. There is an urgent need for the establishment of a process by which sites for new barge fleeting areas in the UMRS can be evaluated in terms of their potential biological impacts.

Boat Traffic Impacts

Although information is available on the levels of commercial boat traffic within various reaches of the UMRS, related information on biological impacts of these traffic levels is almost non-existent. The potential biological impacts of boat traffic are 1) increased oxygen stress to aquatic animals caused by resuspension of sediments, sediment oxygen demand and lower photosynthetic rates, 2) direct effects of turbulence on benthos and fish in main channel and main channel border habitats, 3) decreased ability of sight-feeding fish to find food due to resuspended sediments, A) degradation of backwater habitats due to lateral movement of resuspended sediments, 5) burial of benthic populations due to lateral movement of resuspended sediments, and 6) degradation of near shore and bank communities from wave action or current changes. The magnitude of these effects increases in areas where the main channel is narrow, shallow and characterized by fine sediments. Biological effects due to boat traffic, therefore, are generally more obvious on the Illinois than the Mississippi River and are generally move severe in upstream reaches of the UMRS than downstream reaches. Large pleasure boats, in addition to commercial traffic, also have the capacity to produce many of the biological effects listed above. The smaller displacement and usually shallower draft of pleasure boats limits their sediment resuspension impacts to shallow habitats but in heavily used areas their wave impacts can be substantial. In addition, they are the primary source of traffic-induced wave impacts in side channel and backwater habitats.

Bilge and waste dumping from boats in the UMRS can increase the exposure of aquatic organisms to toxic materials and reduced dissolved oxygen levels if the wastes create oxygen demand. These biological effects are dependent on traffic levels but otherwise difficult to describe in terms of areas within the UMRS.

STATE OF THE ART

Measurement of past and present biological impacts of navigation on the UMRS is limited more by a lack of historical data and time and manpower requirements than the need for special methodologies. In addition, cause and effect relationships that result in biological impacts can only be assessed after first having a clear understanding of the physical and chemical mechanisms involved (see section I).

The prediction of future biological impacts of navigation requires the baseline information noted above and a combination of 1) studies designed to identify short and long term cause and effect relationships and 2) monitoring programs to document long-term trends. This section is included to summarize our present ability to measure biological impacts of navigation on the UMRS.

Measurments of Biological Impacts

Project Construction, Operation, and Maintenance

Habitat changes, in units of surface acreage, caused by inundation that followed the construction of the lock and dam system on the Mississippi and Illinois Rivers have been adequately documented by the U.S. Corps of Engineers (1978, 1979). Habitat changes have generally been calculated by making planimetric comparisons of pre- and post-impoundment aerial photographs or maps. Such measurements, therefore, are dependent upon the availability of suitable photographs or maps. The measurement of future habitat changes on the UMRS will undoubtedly be enhanced by infrared aerial photography techniques, some of which have already been used to inventory habitats of the Upper Mississippi River in 1977 (Hagen et al. 1977).

Present rates of habitat loss or gain due to sedimentation have been measured in some areas of the UMRS (GREAT I Sediment and Erosion Control Work Group 1979, Eckblad et al. 1977, Bellrose et al. 1979). Sedimentation rates can be determined by comparing bottom contour levels of a river reach at different periods of time or by radio isotope (Cs-137) analysis (GREAT I Sediment and Erosion Control Work Group 1979). Measuring the relative contribution of sources of sediment in any one reach or habitat of the UMRS is much more difficult and probably requires a comprehensive sediment budget study of the UMRS including analysis of sediment composition and the use of sediment tracers. GREAT I Sediment and Erosion Control Work Group (1979) did distinguish aquatic areas in pools 5-10 that had been lost due to fine sediment deposition from those lost due to dredge spoil disposal.

Seagle et al. (1980) described the use of side scan sonar methods to investigate aquatic habitats in the UMRS. If the products of such methods can be quantified, they could provide an accurate and cost-effective means of observing the general conditions of aquatic habitats in the UMRS.

Known changes in aquatic and terrestrial populations related to project construction, operation, and maintenance have been measured using a variety of sampling methods, direct observations, or analysis of historical population estimates such as commercial harvests. However, relatively few biological studies have had as their primary objective the assessment of construction, operation or maintenance impacts. Instead, these impacts have been reported as they have become evident through non-navigation oriented sampling programs. As a result, correlations of long-term trends between populations and project construction, operation or maintenance activities have been mostly limited by a lack of control groups which were exposed to singular or no impacts. Exceptions to this general rule include recent studies designed to investigate the biological impacts of wing dams, side channel openings and pool water level regulation practices (GREAT II Fish and Wildlife Work Group 1980).

Adequate methods now exist to measure most aquatic populations in the UMRS. In some cases, our ability to assess biological impacts of project construction, operation and maintenance activities on aquatic populations has recently improved with the development of new sampling techniques. Of particular interest are SCUBA techniques for winter investigations of fish populations and benthic communities (GREAT II Fish and Wildlife Work Group 1980), large river drift methods (Seagle et al. 1980), and main channel fish sampling methods (Summers 1979).

Any study designed to assess the impact of navigation system activity must (depending on the type of organism being studied) address diurnal or seasonal "natural" changes in populations. Likewise, studies to address local impacts on populations must be put into the perspective of the entire UMRS. Few studies on the biological status of the UMRS have incorporated methods which have been standardized over the entire system.

Research on the biological components of river ecosystems has only recently begun to include studies of ecosystem functional components (i.e. energy production and flow) in addition to structural ecosystem components (i.e. populations) (Cairns 1977, Cairns et al. 1972). A "River continuum theory" has been proposed by Vannote et al. (1980) that recognizes the dependence of populations in a river reach to the dynamic physical forces typical of that reach and also the dependence of downstream ecosystems on the products of upstream processes. Information that is available on biological effects of navigation likewise is predominately related to population impacts (changes in numbers or diversity) as opposed to impacts related to functional ecosystem components.

Boat Traffic

Very little information exists on the impacts of recreational and commercial traffic on biological components of the UMRS. Many of the <u>potential</u> biological impacts have been identified (Sparks 1975), and the magnitude of some physical effects that could lead to biological impacts at specific sites within the UMRS have been observed (Sparks et al. 1979, Starrett 1971, Link and Williamson 1976). However, the full extent of navigational impacts of the biological status of the UMRS remains largely speculative. Studies are currently underway to determine if commercial traffic increases drift and dislodgement of macroinvertebrates off wing dams in Pools 26 and 9. The Academy of Natural Sciences of Philadelphia (1980) has developed a set of assumptions and criteria for predicting the impacts of commercial traffic on aquatic populations in the Ohio River. These assumptions and predictions were based on modeled physical impacts rather than being experimentally derived.

Again, the impacts of boat traffic on aquatic or semi-aquatic populations requires time, manpower, and appropriate experimental designs using relatively standard population estimation methods rather than new methodologies.

INFORMATION GAPS

The purpose of this section is to list specific information gaps related to the biological effects of navigation on the UMRS. In addition to sections on project construction, operation and maintenance, and boat traffic it includes a section on gaps in our basic knowledge of the biological status of the UMRS.

Gaps Related to the Biological Status of the UMRS

1. Although a wealth of information exists on the biological status of the UMRS, much of this information is difficult to access. Information that can't be readily accessed is nearly equivalent to no information at all, or an information gap.
2. The size of the UMRS has previously prevented comprehensive biological studies from being conducted on the system as a whole. While local or regional inventories do provide baseline biological information (particularly species lists and population counts), certain limitations in using such local information at the system-wide level will always exist. Certain system-wide inventories of habitats and populations which include standardized methods, sampling schedules and analyses are necessary to overcome these limitations.
3. Most of the information existing on aquatic populations in the UMRS relates to relatively few biological taxa. Information on fish populations is adequate, but other extremely important aquatic taxa such as molluscs, insects, periphyton, phyto- and zooplankton require more frequent monitoring.
4. The biological status of the UMRS is currently changing due to pressures (i.e. land use, municipal, industrial, and recreational development) besides those related to the navigation system. Predictions made now about the future biological impacts of navigation could be rendered

meaningless if major changes in the biological status of the system occur due to these other pressures. Regarding this point, a lesson can be learned from the non-predictable die-off's of benthos and aquatic plants on the Illinois River in the 1950's (Mills et al. 1966). Since biological predictions therefore, are so tentative, a system to regularly check the status of the system and verify predictions should be established.

5. Aquatic habitats in the UMRS on a system level are not well known. U.S. Corps of Engineers hydrographs are available for main channel and main channel border areas (U.S. Corps of Engineers, St. Louis, 1977a, b). But detailed standardized below-water-level contour maps for off-channel areas are needed. Far more basic biological information is needed on ecosystem functions (energy production and flow) even before we can begin to assess the potential impacts of navigation on the aquatic ecosystem of the UMRS.

<u>Gaps Related to Biological Impacts of Project Construction, Operation and Maintenance</u>

1. To what extent is the construction of the lock and dam system on the UMRS presently affecting sedimentation rates in backwater areas? Sedimentation rates in some backwater areas are known but how much of the sedimentation problem is due to project construction as compared to increased sediment input from tributaries, floods, dredging activities, or lateral movements of sediments created by boat traffic?

2. Given that sedimentation and channel constriction are continually decreasing aquatic habitats in the UMRS, how much water acreage in various habitat types will be lost (and at what rates) in the future at present navigation levels? How much will expansion of the navigation system increase the rate or magnitude of these losses?

3. How much aquatic habitat loss (based on present conditions) is acceptable

on the UMRS at the system level? 10%? 50%? 90%?

4. What local aquatic habitats are critical areas that should he preserved? Given X amount of loss of aquatic habitat in the UMRS, how much will it cost in the future to restore or rehabilitate that amount of aquatic habitat?
5. What changes in aquatic populations in terms of abundance, diversity and species composition will accompany loss of aquatic habitats?
6. How do specific pool regulation strategies benefit different aquatic populations and communities?
7. What aquatic populations will be affected by impacts of winter navigation?
8. To what magnitude will these populations be affected?
9. How do the overall ecosystem functions of protected stabilized shorelines compare to that of unprotected shoreline ecosystems?
10. How do the overall functions of aquatic ecosystems on wing dams compare to that of sand/silt substrates?
11. What are the potential biological impacts of barge fleeting areas and. what site specific factors are necessary to predict their magnitude?

<u>Gaps Related to Biological Impacts of Boat Traffic</u>

1. Are boat-generated waves (commercial and recreational) presently limiting benthic aquatic vascular plant or other near-shore populations in the UMRS?
2. Do traffic generated drawdowns adversely impact benthic or shoreline communities in the UMRS?
3. To what extent do drawdowns affect the exchange of biological populations between backwater and main channel areas?
4. Are the above impacts (if any) due primarily to exposure to air, physical disturbance, increased turbidity or increased oxygen stress?
5. To what extent are aquatic habitats and populations in the UMRS

adversely impacted by lateral movements of sediments produced by traffic events?

6. To what extent are fish, benthos, plankton, and drift populations in main channel and main channel border habitats impacted by physical turbulence, velocity and pressure changes, and increased turbidity created by traffic events.

7. What are the present rates and system-wide distributions of traffic accidents, spills, and waste dumpings of biologically hazardous materials to the UMRS and how will the rates increase with expansion of the navigation system?

STUDIES TO FILL INFORMATION GAPS

The studies described here are organized by type of impact rather than type of navigation activity. Studies are prioritized in the following sub-section. As in the first section of this report, no future inflation factor has been built into the budget estimates. Impacts requiring long-term monitoring are indicated by length of study period.

Studies to Characterize the Biological Status of the UMRS

S1. Information Processing - establishment of a centralized library with computer searching capability, UMRS habitat and population data bases, reference maps and aerial photographs.

Site - At Upper Mississippi River Basin Commission or Upper Mississippi River Conservation Committee headquarters.

Study Period - continuous

Manpower - 4 man-years/year during the first 2 years
2 man-years/year after the first 2 years

Funding - $270,000/yr for the first and second year
70,000/yr after second year

S2. Establishment of a system-wide biological monitoring program for the UMRS.

Site - Selected sites, throughout the UMRS, representing different reaches and habitats including wing dams and stabilized banks.

Study Period - continuous

Manpower - variable depending on season and state resources but a minimum of 3 man-years/year (1 coordinator and 2 assistants) for direction and administration of the program and probably 10-12 man-years/year for field work.

Funding - $362,000/year

Studies to Fill Gaps Related to Project Construction, Operation and Maintenance

C1. Study to address sedimentation and loss of aquatic habitats and populations in the UMRS. Identify relative sources of sedimentation in various reaches and habitats, predict how much habitat loss the system can withstand, predict future costs of rehabilitating/restoring lost habitats, predict relationships between habitat losses and population changes.

Site - selected sites throughout the UMRS.

Study Period - 6 years

Manpower - 5 man-years/year

Funding - $996,000

C2. Biological impacts of pool regulation in the UMRS. Analysis of past programs, six years of test practices.

Site - selected pools and habitats within the UMRS

Study Period - 6 years

Manpower - 2 man-years/year

Funding - $432,000

C3. Winter navigation study, 2 years for identification of potential impacts and critical areas, and 4 years for demonstration projects.

Site - several sites to represent different winter navigation seasons on the UMRS.

Study Period - 6 years

Manpower - 2 man-years/year during the first 2 years
4 man-years/year after the first 2 years

Funding - $610,000

C4. Barge fleeting area studies, identification of potential impacts, and impact measurement at selected sites.

Site - combination of post-impact sites and several pre- and post-impact sites.

Study Period - 4 years

Manpower - 2 man-years/year for first 2 years

3 man-years/year for last 2 years

Funding - $330,000

Studies to Fill Gaps Related to Boat Traffic Impacts

Note: Studies to investigate the impacts of traffic-generated resuspended sediments on aquatic habitats and populations were included in the study of sedimentation (C1) described earlier.

T1. Wave and drawdown effects on benthic, fur bearer and shoreline populations in the UMRS.

Site - selected representative sites throughout the UMRS

Study Period - 4 years

Manpower - 8 man-years/year

Funding - $916,000

T2. Study of impacts of traffic-induced drawdown on exchange of water, plankton and organic material between main channel and off channel areas.

Site - selected side channels, sloughs and backwaters of the UMRS (maximum of 4 sites)

Study Period - 3 years

Manpower - 4 man-years/year

Funding - $309,000

T3. Studies of the impacts of traffic-generated turbulence (velocity and pressure changes) on main channel populations (i.e. fish, plankton, drift organisms).

Site - selected main channel sites in the UMRS (maximum of 4 sites)

Study Period - 3 years

Manpower - 6 man-years/year .

Funding - $498,000

T4. Studies to identify present and predicted future waste loadings from commercial and recreational traffic and their biological impacts on the UMRS.

Site - not applicable

Study Period - 2 years

Manpower - 3 man-years/year

Funding - $237,000

PRIORITIZATION OF INFORMATION GAPS

Four criteria were used to assess the biological study needs related to navigation listed above and assign them to one of three categories: urgent, necessary or beneficial (the same ranking system used for recommended physical and chemical studies in Section I). The four criteria used were: known magnitude of impact on UMRS, proportionality of impact to navigation system status, system-wide degree of impact, degree of present capability to measure impacts. The study needs related to the biological status of the UMRS were not directly comparable to those related to navigation impacts using these criteria. These study needs were placed in the "necessary" category, however, because the information generated by them is essentially necessary for most of the other assessments.

Table 1 contains a prioritization summary for the studies. A priority rating system of 1 (low) to 3 (high) was used for each of the criteria. Priority points for each study were summed. Studies obtaining 11-10 points were given "Urgent" status. Those obtaining 9-8 points were given "necessary" status and those obtaining 7-6 points were given "beneficial" status.

Table 1. Prioritization summary of biological studies. Priority points (l=low, 3=high) were assigned for four criteria. Studies related to the general biological status of the UMRS were placed in the "necessary" class because their products are required for the navigation impact studies.

General Biological Studies		Study Priority Class
S1.	Information Processing (Library and computer facility)	necessary
S2.	Monitoring Program	necessary

Biological Impacts of Navigation Studies		Criteria for Biological Impact Study A	B	C	D	Total	
C1.	Sedimentation impacts	3	2	3	3	11	urgent
C3.	Winter Navigation impacts	3	3	2	2	10	urgent
C4.	Fleeting Area impacts	2	3	3	2	10	urgent
T1.	Wave & drawdown impacts on benthos, plants, etc.	2	3	2	2	9	necessary
T3.	Turbulence impacts	2	3	2	2	9	necessary
T2.	Drawdown impacts on exchange of biological material between main channel and off-channel areas.	2	3	2	2	9	necessary
T4.	Accidents, spill impacts	1	3	2	1	7	beneficial
C2.	Pool regulation impacts	1	2	2	1	6	beneficial

Criteria A = potential or known magnitude of impact
Criteria B = proportionality of impact to status of navigation system
Criteria C = system wide distribution of impact
Criteria D = present capability of measuring impacts

SUMMARY

Ten studies to provide information necessary to fill information gaps related to biological impacts of navigation on the UMRS have been identified, described and prioritized. Studies dealing with sedimentation, winter navigation and fleeting areas (total funding = $1,936,000 over 4-6 years) were considered urgent. Two studies to continuously process information and monitor populations and habitats in the UMRS were considered necessary. These two projects will require a total of $632,000/year for the first two years, and $432,000/year thereafter. Studies to determine impacts of boat generated waves, drawdowns and turbulence over periods over 3-4 years at a total cost of $1,723,000 were also considered necessary. Studies of pool regulation impacts, and the impacts of waste loadings from commercial and recreational traffic (total cost of $669,000 over 3-6 years) were considered beneficial.

LITERATURE CITED

Academy of Natural Sciences of Philadelphia. 1980.' Analysis of the effect of tow traffic on the biological components of the Ohio River. Huntington: U.S. Army Corps of Engineer District. 47pp.

Allen, K. O. and J. W. Hardy. 1980. Impacts of navigational dredging on fish and wildlife: A literature review. U. S. Fish and Wildlife Service. 81pp.

Bellrose, F.C., F.L. Paveglio, Jr., and D.W. Steffeck. 1979. Waterfowl population and the changing environment of the Illinois River Valley. Illinois Natural History Survey Bulletin 32:1-53.

Cairns, J., Jr. 1977. Quantification of biological integrity. In: The Integrity of Water, R.K. Ballentine, and L.J. Guarraia, eds. U.S.E.P.A.

Cairns, J., Jr., G.R. Lanza, and B.C. Parker. 1972 Pollution related structural and functional changes in aquatic communities with emphasis on freshwater algae and protozoans. Proc. Acad. Nat. Sci. Pila. 124(5):79-127.

Eckblad, J.W., N.L. Peterson, K. Ostlie, and A. Temte. 1977. The morphometry, benthos and sedimentation rates of a floodplain lake in Pool 9 of the Upper Mississippi River. Amer. Midl. Nat. 97:433-443.

Fremling, C.R. 1974. The impact of man on the ecology of the Mississippi River. Encounters: A Journal of Regional Interaction 2:23-25.

GREAT I, Sediment and Erosion Work Group. Sediment and Erosion Work Group Appendix, Upper Mississippi River. 1979. 107pp.

GREAT I, Fish and Wildlife Work Group . Fish and Wildlife Work Group Appendix, Upper Mississippi River. 1979. 605pp.

GREAT II, Fish and Wildlife Work Group. Fish and Wildlife Management Work Group Appendix, Draft, Upper Mississippi River. 1980. 296pp.

Green, W.E. 1960. Ecological changes on the Upper Mississippi River fish and wildlife refuge since inception of the 9-foot channel. Revised. U.S. Dept. Interior Fish and Wildlife Service. 14pp.

Hagen, R., L. Werth, and M. Meyer. 1977. Upper Mississippi River habitat inventory. IAFHE RSL Research Report 77-5. 18pp.

Hirsch, N.D., C.H. DiSalvo, and R. Paddicord. 1978. Effects of dredging and disposal on aquatic organisms. U.S. Army Corps of Engineers Waterways Experiment Station Tech. Report DS-78-5.

Link, L.E., Jr. and A.N. Williamson, Jr. 1976. Use of automated remote sensing techniques to define the movement of tow-generated suspended material plumes on the Illinois and Upper Mississippi Rivers. Vicksburg, MI: Army Engin. Waterways Experiment Station. 71pp.

Midwest Research Institute. 1978. Environmental and social consideration of Mississippi River year-round navigation porgram. Final report. Rock Island, IL: U.S. Army Corps of Engineers, Rock Island District. 72pp.

Mills, H.B., W.C. Starrett, and F.C. Bellrose. 1966. Man's effect on the fish and wildlife of the Illinois River. Illinois Natural History Survey Biological Notes No. 57. Urbana, Illinois. 24pp.

Morton, J.W. 1977. Ecological effects of dredging and dredge spoil disposal: a literature review. Tech. Paper 94, U.S. Fish and Wildlife Service. 33pp.

Seagle, H.H., Jr., K.S. Lubinski, and M.C. Reese. 1980. Phase II, Task 1 Preliminary sampling and site selection Pool 26. Submitted to Environmental Work Team, Upper Mississippi River Basin Commission. 156pp.

Sparks, R.E., F.C. Bellrose, F.L. Paveglio, Jr., M.J. Sandusky, D.W. Steffeck, C.M. Thompson. 1979. Fish and wildlife habitat changes resulting from construction of a nine-foot channel on Pools 24, 25, and 26 of the Mississippi River and the Lower Illinois River. St. Louis, MO: US Army Corps of Engineers. 208pp.

Starrett, W.C. 1971. A survey of mussels (Unionacea) of the Illinois River a polluted stream. Illinois Nat. Hist. Sur. Bull. 30:1-403.

Summers, S.A. 1979. Study of fish in the main channel of the Mississippi River between river miles 500.0 and 513.5, interim report. Corps of Engineers, Rock Island District. 88pp.

U.S. Army Engineer Division, North Central. 1978. Summary report of fish and wildlife habitat changes resulting from the construction of a nine-foot channel in the Upper Mississippi River, Minnesota River, St. Croix River, Illinois Waterway. Chicago, IL: U.S. Army Engineer Division.

U.S. Army Engineer Division, St. Louis. 1979. Quantitative report, Upper Mississippi and Lower Illinois Rivers Pools 24, 25, and 26. Terrestrial and aquatic land use and habitat change as a result of the nine-foot channel project. U.S. Army Engineer District, St. Louis. 17pp.

U.S. Corps of Engineers, St. Louis. 1977a. Hydrographic survey maps of the Illinois River. U.S. Army Corps of Egnineers, St. Louis District.

U.S. Corps of Enginner, St. Louis. 1977b. Hydrographic survey maps of the Mississippi River. U.S. Army Corps of Engineers, St. Louis District.

Vannote, R.L., C.W. Minshall, K.W. Cummins, J.R. Sedelle and C.E. Cushing. 1980. The river continuum concept. Can. J. Fish. Aquat. Sci. 37:130-137.

Yeager, L.E. 1949. Effect of permanent flooding in a river-bottom timber area. Bulletin of the Illinois Natural History Survey 25(2):33-65.